

# BROADER BORDER THINKING

**A design firm's visits to existing U.S. border stations let the GSA to reconsider some of its ineffective guidelines for exterior lighting. The result is a new design standard.**

**By Mary Claire Frazier**  
(published in LD+A August 2009)



Glare from unshielded luminaires, excessive illuminance levels and lack of transitions zones to darker areas hinder the ability of officers in Secondary Inspection areas to perceive activities outside the immediate area.

Land Ports of Entry (LPOE), commonly called border stations, are scattered along the northern and southern US borders wherever a public road crosses the border. Some are relatively sleepy little facilities with one or two traffic lanes, while others range up to 20 non-commercial lanes plus extensive commercial areas. The age of these facilities varies widely.

The exterior lighting technologies and resultant energy use cover the gamut from high pressure sodium and even mercury at older stations to ceramic metal halide and LED at newer stations. What binds them together, at least in theory, is that they are supposed to comply with lighting requirements documented in two publications that are updated periodically. These documents are the *Facility Standards for the Public Building Service, P100-2005 (P100)* and the *U.S. Land Port of Entry Design Guide 2006 (Design Guide)*, both published by General Services Administration (GSA) and distributed to design teams working on new and remodel LPOE projects. The goal of these documents is to facilitate the design of the best possible facilities for the accurate and efficient processing of vehicles and people crossing the border.

These facilities are complex visual environments with critical lighting needs. In some areas, split-second decisions based on instinct and subtle clues are required of inspectors. In other areas, minute details of vehicles and their contents must be perceived, while in commercial areas, vast spaces must be provided for trucks to turn. The traditional approach has been to require quite high levels of horizontal illuminance without reference to other important design criteria such as vertical illuminance, uniformity, transition/adaptation zones, and glare control.

In 2006 Candela started working with architect Bohlin

Cywinski Jackson on the design for a new facility to replace the Peace Arch LPOE on the Washington border, the main point of entry between Vancouver, British Columbia and Seattle, WA (see sidebar). The existing facility was outdated and not up to the task of accommodating the growing population of "Cascadia" or the crowds expected for the 2010 Winter Olympics in Vancouver.

The exterior lighting quickly became a major area of concern as we discovered the lighting requirements in the *P100* and *Design Guide*, and found ourselves pressed to figure out how the project could achieve the LEED Sustainable Sites credit 8.1. The requirements for exterior lighting were written and revised piecemeal over many years and contain much that is unsupported, nonsensical and outright incorrect. They lack references to good lighting design principles while encouraging glare and excessive energy use. Horizontal illuminance levels as high as 50 footcandles were required at inspection areas with minimal adaptation considerations. Although the guidelines nominally referenced IES recommendations, there was no obvious relationship between the metrics in the *Design Guide* and IES recommendations for exterior lighting or specific tasks.

Faced with a perceived need to meet these guidelines and contribute to the LEED requirement, we decided to stick our necks out and tell GSA what the real issues were and how they ought to be addressed to create a good visual environment. To that end, we crafted a memo that explained how we could achieve a superior visual environment with lower light levels and substantially less energy use if we were allowed to follow the principles of visual perception, energy effective design, controls and IES recommended practices. The memo caught the attention of



A typical view from Primary Inspection toward oncoming traffic. Good uniformity and a smooth transition zone to darkness beyond are critical to an officer's ability to perceive oncoming threats.

a forward-thinking person with authority to contract us to rethink the exterior lighting at these facilities.

#### *Five Site Surveys*

We began a process that included surveys at existing border stations, interviews with inspecting officers, review of current research, and evaluation of the application of IES task references to specific visual tasks at the facilities. We found remarkable and consistent evidence at existing facilities to support our initial belief that factors other than high horizontal illuminance are required for maximum visibility.

Our study included site visits to five facilities: two on the Texas border and three on the Washington border. At each location we measured horizontal and vertical illuminance at critical locations, and took comparative luminance measurements of luminaires and background areas surrounding positions where officers were performing inspections. We were careful to observe the specific visual tasks that officers need to perform at each location. We also interviewed the officers who were on duty, enquiring as to their perceptions of the lighting and how they adapted to it.

The most surprising finding to us was that almost none of the light levels required by the governing standards were met except at sporadic locations. In our design of the Peace Arch project we had assumed that we were responsible for meeting those levels as well as creating a good nighttime environment for the officers. It became obvious to us that at most of these facilities, the lighting was not designed by professional lighting designers who understand the components of a visual environment that enhances visibility.

In our interviews with officers, we found that even where horizontal illuminance was below the required level, the officers felt better about the lighting if there was adequate

vertical illuminance and good uniformity. While the officers frequently stated the need for more light in critical situations, they were cognizant of the way in which glare and lack of uniformity interfered with their ability to see. Their stated need to see across the site toward approaching vehicles and pedestrians was an important point for them that was not addressed in any of the standards.

Our review of current research brought out some interesting conditions. There is a growing body of evidence that light in the white to blue range of the visible spectrum provides better nighttime visibility at Mesopic light levels which affect most nighttime conditions. Unfortunately, none of the research is definitive, and the researchers are careful to caution that their results apply only to the specific conditions investigated. These conditions are primarily related to driving conditions, although some articles address the perception of pedestrian safety on college campuses. In the absence of any industry-accepted standards or metrics for nighttime perception, researchers recommend that designers continue using daytime standards while applying their best professional judgment.

Pulling all this information together, our initial report summarized the lessons learned and resultant recommendations about ways in which the *Design Guide* ought to be revised to make it a better tool for design teams. It also included a summary of IES recommendations for using specific visual tasks to determine how much light is required and a discussion of visual issues involved in the various functional areas at LPOEs. The most important rules for achieving improved visibility and energy efficacy that grew out of the study are the following.

- Designers need to understand visual and physical tasks being performed in order to apply IES recommendations, so descriptions of tasks at each functional area need to be in the document.
- The perception of adequate light depends on vertical



Floodlights mounted on a Primary Inspection canopy, aimed at the inspecting officer, create a source of glare that impedes an officer's ability to detect details.

illumination and uniformity, so those criteria need to be added.

- Designers need to know the parameters of the metrics they are required to follow, so all metrics need to be identified as average, minimum, min:avg, etc.
- The highest required light levels are not necessary at all times, so switching and dimming controls should be used to allow for multiple levels as needed.
- Because the visual environment is so critical at these facilities, a professional lighting designer should be a required design team member.
- Clearly defined metrics for achieving and proving compliance are as important as the requirements themselves.

### *The Final Document*

One of the problems with describing requirements of any kind with a document described as a "design guide" is that people think "it's only a guide, not a requirement." In fact, in the inevitable VE process on the Peace Arch project, the contractor said exactly that to us in response to our insistence that we need to provide lighting to meet the light level requirements. Consequently, the document is being re-christened "the design standard." The entire document addressing all aspects of the Land Ports of Entry is being rewritten with that in mind - no more "should"; just

"must." In a standard all criteria must be clearly defined and measurable, and compliance must be verifiable.

The official *Design Standard 2009* is supposed to be released in a couple of months. Architects for specific projects are given access to download it but are not allowed to provide it for circulation outside the design team. It is not available to the general public.

The lighting requirements established in the standard are derived from the survey findings and analysis as well as our conviction that the document needs to avoid restricting design decisions. All of the applicable functional areas are addressed, including parking, commercial and non-commercial inspection, building perimeter, vehicular and pedestrian traffic areas, perimeter of the buildings and site, and transition zones between all areas visually connected with each other. Inspection areas presented the best opportunities for reducing energy use because of the high illuminance requirements set for those areas in the *Design Guide*.

At Primary Inspection, officers have a variety of visual task they must perform quickly. Some—like obtaining an impression from a driver's facial cues and body language—are dependent on the lighting in the immediate area of the inspection booth. Others—like judging potential danger

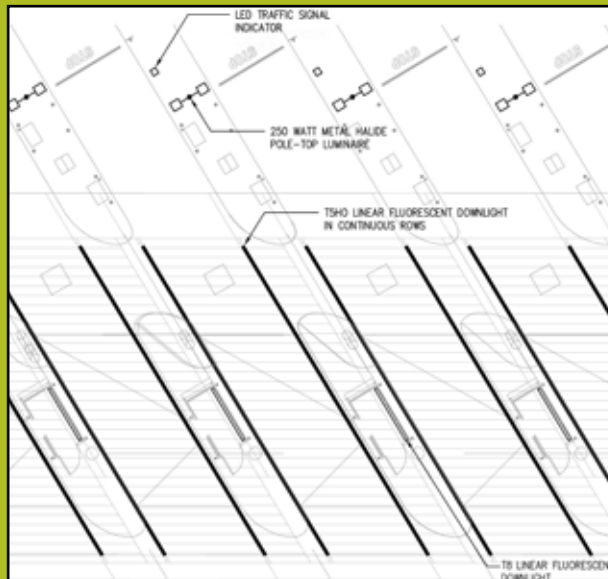
# BORDERLINE REDESIGN

Mary Claire Frazier describes how the project team redesigned the Peace Arch LPOE using the new standards.

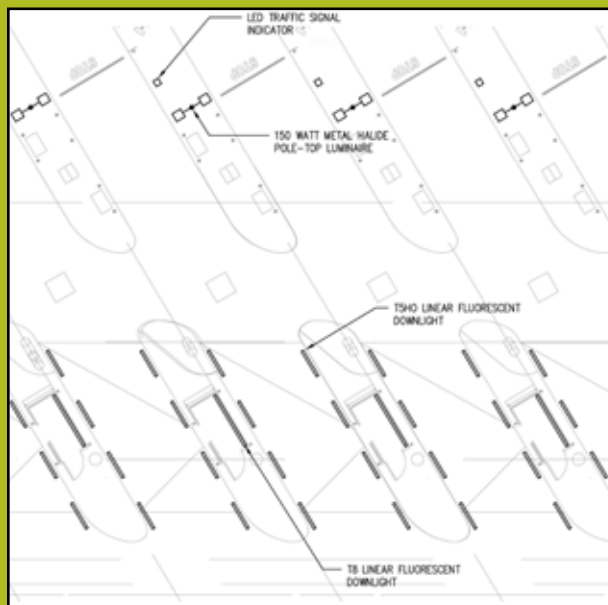
We had designed the Peace Arch LPOE project along the Canadian and U.S. border in Washington to meet the requirements of the 2006 Design Guide and best practices for a good visual environment. Consequently, there were areas we considered over lighted. With GSA's agreement, we undertook a review and redesign of all the exterior lighting with the goal of bringing the entire site into compliance with the standards we had written. Substantial changes were made to four areas: primary approach; primary inspection; secondary inspection; and the pedestrian walkway between the parking lot and building.

In the approach to Primary Inspection we discovered that we needed to add poles and fixtures to bring the area into compliance. Originally, we had chosen to use relatively low light levels in the area because the highway leading to it was not illuminated. We didn't want to create a sudden increase in light levels, so we used a very slow developing transition zone from nothing to 35 fc. After our experience during the survey with the actual visual tasks required of the officers, we realized that seeing across this area from the inspection booth was more important than we had realized. We increased the density of pole-top fixtures. This is the only area where the cost and energy use increased.

At Primary Inspection we were able to substantially decrease light levels and improve the transition to adjacent zones. The quantity of luminaires was decreased by 63%, and thirteen



Original lighting layout for Primary Inspection at Peace Arch Land Port of Entry.



Revised layout for Primary Inspection at Peace Arch Land Port of Entry.

pole-top fixtures were reduced from 250 to 150 watts.

At Secondary Inspection we were able to not only reduce light levels, but also add controls that allow the overall light levels to be kept at a basic level of 10 fc, with local switches that can be used to raise limited areas to 30 fc, and inspection tables to 50 fc. Forty-eight percent of the fixtures were deleted, although 252 linear LED luminaires were added for task light over the inspection tables. This resulted in a net reduction of 16 percent of the luminaires.

Along the pedestrian path between the parking lot and building entry, bollards were replaced with pole-top fixtures to increase the vertical illuminance and uniformity to comply with the standards. Although this affected what had been a deliberate design decision to use the bollards, our background experience now made it obvious that the additional vertical illuminance available from pole-top fixtures was important, and no additional cost or energy use was incurred by this change.

The redesign resulted in a total initial savings of approximately \$90,000

or 14 percent of the installed fixture cost, and 16,773 watts or 22 percent of the exterior lighting power for the project. This power reduction assumes all luminaires in Secondary are on even though the multi-level switching will reduce that substantially. Reductions in operational costs have not been projected, but should be substantial. During our future trips to Vancouver, BC, we expect that waiting in line for inspection will be a more pleasant experience.

from on-coming vehicles, are dependent on lighting across large areas. In-depth inspections occur at Secondary Inspection, so at Primary there is not a need for the kind of light levels that perception of fine detail requires. Rather, the overall visual situation that affects the officer's field of view and peripheral vision contributes to the ability to take in everything. As a result, glare, excessive contrast ratios and lack of uniformity are destructive. The new standards address this by requiring a moderate light level at the immediate point of inspection, and a gradually decreasing level over the approaching and exiting roadways. Vertical

**The requirements for exterior lighting were written and revised piecemeal over many years and contain much that is unsupported, nonsensical and outright incorrect. They lack references to good lighting design principles while encouraging glare and excessive energy use.**

illuminance and uniformity requirements are defined throughout the area.

At Secondary Inspection, there are different levels of visual tasks, and each can be assigned to a specific area of definable size. This allows for multiple levels of switching that will provide energy savings without negatively affecting visibility. The original requirement for 50 fc for inspection actually only applies to tables that allow officers to inspect vehicle contents in detail. For the rest of Secondary, lower light levels are actually beneficial because officers use their flashlights to throw grazing light along vehicle surfaces to look for inconsistencies that would indicate alterations to the vehicle. With brighter lights, less contrast makes this more difficult. In drive aisles, even less illumination is required as no inspection takes place there.

These different functions allow the illumination requirements to be divided into three levels; basic, enhanced, and task, with 10fc, 30fc and 50fc requirements respectively. Basic includes the drive aisle, enhanced includes the parking areas, and task is limited to the inspection tables. The enhanced area is required to have two levels at 10fc and 30fc, and be divided into control zones that "cover an area sufficient for seeing all sides of a vehicle or vehicles in an area sized for efficient circuiting." This makes it possible to locally switch areas where vehicles are parked so they have 30fc, leaving the rest of the area at 10fc. These steps allow for good visual transition across the area.

Requirements for transition zones between functional areas are included in the document. Vertical illumination and uniformity requirements are included for all locations where they are important. For pedestrian areas in particular, the need for facial recognition necessitates good vertical illuminance. Increased illuminance requirements around the perimeter of the buildings allow officers to determine potential threats where greater levels of activity are present.

Technical guidance for the design team is provided so that specific conditions not addressed in the standard can be viewed through an appropriate filter. References to IES documents encourage research by the design teams to clarify the specific visual situations unique to each project.

The new requirements will substantially reduce energy use at border facilities by reducing illuminance levels, controlling glare, improving uniformity, and introducing stepped controls and task lighting. Visibility will be improved with lower light levels when they are applied

within a complete framework of lighting requirements that work together. Rather than a simple list of minimum illuminance levels, designers will be required to address the complete visual environment and verify compliance with all aspects of good lighting design principles. If all requirements are not proven to be met, the design loses the ability to incorporate the lower illuminance levels.

Compliance must be demonstrated with point-by-point calculations, and the specific extent and manner of completing those calculations is specified in detail. The detailed description of the calculation submission requirements not only provides guidance for design teams, but also gives the project's reviewers a framework to follow in verifying compliance.



About the Author: Mary Claire Frazier, IALD, Member IES (1995), LEED AP, is design principal at Candela Lighting Design and Consulting based in Seattle, WA. She has more than 25 years of experience as an independent lighting designer and instructor.